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ABSTRACT

The Biological Sciences Curriculum Study designed, developed, and field-tested a series of nine curriculum resource units for a semester program called "Innovations: The Social Consequences of Science and Technology (IST)." The units were designed for use by students and teachers in the 11th and 12th grades and at the junior college level: either in existing science or social studies courses; or as the basis of an interdisciplinary course of science, society, and technology. Unit topics include: science, technology, and society; television; low-head hydropower; day care; energy-technologies, dilemmas and options; human reproduction; computers and privacy; biomedical technology; and food technology. Presented in this final report are criteria used in identifying topics of interests, an overview of formative evaluation procedures, content reviews, information on field tests, and student and teacher feedback for each unit. Findings indicate that units were enthusiastically received by both students and teachers and that, as a result of formative evaluation data collected, information was provided for revising the experimental materials to produce a commercially available product. (JN)

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BSCS, Richard R. Tolman terminated 12-31-81

FINAL EVALUATION REPORT

INNOVATIONS: THE SOCIAL CONSEQUENCES OF SCIENCE AND TECHNOLOGY

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INTRODUCTION

Under an eighteen month grant (SED 7918968) from the National Science Foundation, the Biological Sciences Curriculum Study (BSCS) designed, developed, and field tested a series of curriculum resource units for students and teachers to be used as a semester program, Innovations: The Social Consequences of Science and Technology (IST). The resource units deal with recent scientific and technological "innovations" and their social consequences. The materials were designed for use at the 11th and 12th grades and junior college level, either in existing science or social studies courses, or as a basis for an interdisciplinary course on science, society, and technology.

The program consists of nine resource units containing a variety of student materials including various combinations of printed, audio tape, visual aids, and hands-on components. Each unit was prepared with five organizing questions in mind. They were: 1) What is it? (how does it work), 2) How does it affect me (personal significance), 3) How does it affect us (societal significance), 4) How valuable to us is it?, and 5) What might be its future?

Table 1 below provides the title of each of the resource units and the approximate class time planned for each.

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Table 1.

Module	Time
Science, Technology, and Society (an introductory module)	3 weeks
Television	3 weeks
Day Care	3-4 weeks
Low-Head Hydropower	2-3 weeks
Computers and Privacy	3 weeks
Human Reproduction: Social and Technological Aspects	3 weeks
Energy: Technologies, Dilemmas, Options	3 weeks
Food Technology	2 weeks
Biomedical Technology	3 weeks

These nine topics were selected incorporating work already completed by the Office of Technology Assessment (OTA) as a resource of technical information and assessment. It was the judgment of the project staff that use should be made of work completed or in progress by OTA, NSF, and other educational groups that had identified needs and priorities in this field. These groups already had invested large amounts of time, money, and expertise in this area. In identifying topics that were of interest, teachable, and representative of current issues of science, society, and technology interactions, the following criteria were used:

-- Does the innovation involve a major impact of technology?

-- Does student and teacher interest exist or can it be generated?

-- Does the technology impact significantly on human needs and quality of life?

-- Can a maximal number of the five organizing questions for the curriculum materials be addressed?

-- Can the resource unit be developed within the procedural plan and time line?

To address the question of student and teacher interest, a survey of possible topics was conducted among participants at the 1980 National Council of Social Scientists and among science and social science teachers in the Jefferson County and Boulder Valley, Colorado, school districts. The survey listed twenty-one possible topics and provided six blanks so additional topics could be entered by the respondent. Participants were asked to mark the topics they would use with their classes and that would maintain student interest. Eighty-five participants responded to the survey. The twenty-one topics as well as the ones added by respondents were rank ordered. Using this information, the information obtained from OTA and NSF, and the criteria identified by the project staff, the previously mentioned nine topics were selected as the units to be developed.

FORMATIVE EVALUATION

Overview

The evaluation of Innovations: The Social Consequences of Science and Technology was considered an integral part of the development process. The evaluation design provided for securing data from teachers, students, classroom observations, and content experts. The data obtained from these sources will enable the curriculum developers to improve the effectiveness of the instructional materials prior to commercial publication. All data were coded on optical scanning forms and read onto a magnetic tape at the University of Colorado Testing

Center. The tapes were then used to enter the data into the Cyber 720 computer at the University of Colorado Computing Center. The Statistical Package for the Social Sciences (SPSS) subroutines were used for data analysis. The results included in this report were synthesized from the SPSS output.

In February, 1980, the first resource unit, Television, was pilot tested in a social science class from the Boulder Valley school district. Twenty-nine students participated in the pilot study. During the three weeks the program was used, at least one staff member was present during each class period to observe and interact with the students and teacher. Information obtained from this pilot test provided the framework both for the revision of the Television unit and for the development of the remaining eight units. Information obtained from the pilot test included additional instructions required for the teacher's guide, worksheet requirements, instructional strategies, unit format, and time limits, all of which were essential to the successful development of the remaining topics.

During March, April, and May, the Television unit was revised and the remaining eight units were completed. The feedback obtained from students and teachers during the pilot test were incorporated in the development process of the other eight units. Close attention was given to the Teacher's Guide, instructional strategies, and areas where students had identified potential problems.

All resource units could not be pilot tested within the limited time available. As a result, the project staff had to make certain

decisions with a limited knowledge base. The most critical of these decisions were those pertaining to the reading materials included in the units. Many of the readings required to adequately cover a topic were considered to be too difficult. However, it was the consensus of the project staff that attempting to syntheize the readings in the short time available would result in misinformation or less than adequate information. From the results of the pilot test it was determined that several of the Television readings that were predicted by the staff to be too difficult for students to handle were not. A decision was made to include as many unabridged readings as possible. Information collected from cloze tests, and from students and teachers during the field test, was used to establish if the readings were appropriate for high school students.

Content Reviews

Beginning in June, 1980, the experimental resource units were provided to content experts for review and critique. Each content expert was asked to examine the unit according to the following criteria: the accuracy and completeness of the information presented; the objectivity, the balance of views; the fairness of views; and areas within the unit most in need of improvement. Table 2 contains the names of the content reviewers for each resource unit.

Table 2. Content Reviewers

MODULE	REVIEWER
Science, Technology, and Society	Dr. Melvin Kranzberg Dept. of Social Science Georgia Institute of Technology Atlanta, Georgia
Television	Dr. David Crippen KCET-TV Los Angeles, California
Food Technology	Dr. James Ayres Goldkist Research Center Lithonia, Georgia
Low-Head Hydropower	Dr. Clair Stalnaker U.S. Fish and Wildlife Service Ft. Collins, Colorado
Biomedical Technology	Dr. Robert A. Burt, JD School of Law Yale University New Haven, Connecticut
Human Reproduction	Dr. Sam Downing, MD Denver, Colorado
Computers and Privacy	Dr. Richard Pollak Minnesota Educational Computing Consortium St. Paul, Minnesota
Day Care	*
Energy	*

*These units were not reviewed for content.

The following is a summary of the reviewers' comments.

Science, Technology, and Society. The major criticisms focused on two points: 1) more emphasis was needed on the science component, and 2) a concern was expressed about the level of abstraction in some, but not all, of the readings.

Television. The review was positive with no major objections.

Food Technology. The reviewer objected to the limited scope of the content. He suggested additional activities and concepts to go beyond the truth-in-labeling investigations in the unit. The content was accurate, but a better balance was needed.

Low-Head Hydropower. The review was positive with no major objections.

Biomedical Technology. The reviewer expressed a concern about the students functioning as amateur lawyers in drawing up contracts. Some of these issues are being ruled on by the U.S. Supreme Court and the recommendation was made that this part of the unit be dropped. The issues raised within the unit were judged to be important for consideration by the students.

Human Reproduction. Some minor recommendations were made concerning changes in terminology. The overall review was very positive.

Computers and Privacy. The content was considered to be important for the student population. It was suggested that a case be presented on the need for gathering information. This would present better balance of the two sides of the issue.

The reviews obtained from the content experts were received at different times. A decision was made to postpone revisions of the units based on the critiques until all of the critiques had been received. It was thought that a reviewer's comments on any specific resource unit could be applicable to some of the other resource units.

Field Test

The IST program was field tested during the fall semester of 1980. Fifteen teachers were selected to field test the program. These fifteen teachers were brought to the BSCS for a two-day orientation conference prior to the implementation of the program. During the orientation, teachers were provided the following: an overview of the project; rationale for the instructional strategies; detailed information on the student and teacher materials; detailed information on the Science, Technology, and Society resource unit; alternative methods for incorporating the resource units in their classes; and hands-on experience with approximately half of the student resource units.

The 15 field test teachers were selected on the basis of location, school setting, and subject area. A concerted effort was made to obtain a balance of social science and science teachers and junior college and high school settings. Table 3 provides information about the field test teachers and their classes. The field test period ranged from eight to twenty-four weeks. depending on teacher schedules. During the field test period evaluative information was obtained from detailed questionnaires completed by teachers and students on each

Table 3. IST Field Test Sites

CLASS	LOCATION	SCHOOL	TEACHER'S SEX	TEACHER'S DEGREE	COURSE	LENGTH OF CLASS PERIOD
1	Suburban	Private High School	M	M.S.	Biology	50-59 minutes
2	Rural	Public High School	M	M.E.	Human Ecology	40-49 minutes
3	Urban	K-12 Laboratory School	M	B.S.	Advanced Biology	50-59 minutes
4	Urban	Community College	M	M.S.	Biology	50-59 minutes
5	Suburban	Public High School	F	M.S.	Psychology	50-59 minutes
6	Suburban	Public High School	F	B.S.	Science	50-59 minutes
7	Suburban	Public High School	F	M.S.	Social Science	50-59 minutes
8	Suburban	Public High School	M	B.S.	World Affairs	50-59 minutes
9	Suburban	Community College	M	M.S.	Biology	60+ minutes
10	Suburban	Public High School	M	B.S.	World History	50-59 minutes
11	Suburban	Community College	F	M.S.	Biology	60+ minutes
12	Rural	Public High School	M	B.S.	Biology	50-59 minutes
13	Suburban	Public High School	M	M.S.	Sociology	50-59 minutes
14	Suburban	Public High School	M	M.S.	Humanity	50-59 minutes
15	Suburban	Public High School	M	M.S.	Biology	50-59 minutes
16	Suburban	Public High School	M	M.S.	Biology	50-59 minutes

resource unit and its teacher's guide. Additional feedback was collected during the site visits by BSCS staff during the field test period.

Teacher Feedback

Each teacher maintained an activity log during the field test as well as completing a module questionnaire. The information obtained from these two sources is summarized below by resource unit.

Science, Technology, and Society

1. Overall student reaction was very positive.
2. Teachers' perceptions indicated that students benefitted and learned from the materials.
3. Some of the concepts were presented at a level of sophistication that was too high for many high school students. However, the more able high school students and nearly all community college students handled the entire unit with few or no problems.
4. The reading level of some, but not all, articles was too high for many high school students. Most community college students did not experience any problems with reading level.

Television

1. Overall student reaction was very positive. Student interest was high.
2. Structure and content of the Teacher's Guide was satisfactory. More help was needed to assist teachers in defining and identifying technical events in TV broadcasting.

3. Most readings were handled successfully by most students. Two articles were identified by most teachers as being too difficult for high school students.
4. Several teachers suggested reducing the number of activities. It was difficult to maintain a high level of student interest throughout the entire unit.
5. Students who were identified by teachers as being "self-motivated" seemed to maintain a higher level of interest than "externally motivated" students.

Low-Head Hydropower

1. Student interest was high throughout.
2. The shortness of the unit was perceived as a positive factor.
3. More all-class work was utilized in this unit than in some of the others.
4. Interest in local water problems was intensified at all field test sites.
5. The teachers indicated a need for additional reference materials.
6. Some difficulties were encountered by students in determining the operating capacities of generating stations.

Day Care

1. The concept of a social technology was received well by both teachers and students.
2. The majority of the readings were within the ability ranges of the students.

3. There was an overall impression of too much reliance on reading in the first half to two-thirds of the unit.

4. The concluding activities, which did not rely on readings, were received very well by the students.

5. Some difficulties were encountered because two few supplies i.e., books, film, etc.) were available for use during the field test. The level of funding made it virtually impossible to supply complete sets of supplementary material for every student.

Energy: Technologies, Dilemmas, Options

1. Overall student interest and enthusiasm for this unit was very high and positive.

2. Some of the readings were perceived to be too long, but the level of difficulty was not a problem.

3. The electric meter supplied with the activity measured kilowatt-hours. The readings were too gross to identify differences in electricity using among small appliances over the limited time available for testing by students. A more sensitive meter will be needed for the commercial materials.

4. Some teachers expressed a need in the Teacher's Guide for more detailed answers to student questions.

5. Student awareness of an energy crisis seems to vary considerably in different parts of the country.

6. Many students in the field test sample experienced difficulty in interpreting graphs and in constructing their own graphs.

7. The "new city" activity contained concepts that were difficult for some students. This is the only activity where concept difficulty was identified as a problem.

Human Reproduction

1. Teacher feedback indicated student interest started and remained high throughout the unit.
2. Overall feedback was very positive. Suggestions that follow were only minor inconveniences.
3. Most teachers commented on the mature manner in which the high school students handled the subject matter.
4. Some teachers felt they needed specific answers to all questions in the student materials.
5. Some teachers recommended that a glossary be included. They sensed that some students did not understand the anatomical vocabulary and were too embarrassed to ask questions about the vocabulary.

Computers and Privacy

1. Teacher feedback indicated a high level of student interest and enthusiasm.
2. Many students became aware of the large amount of information about people, including themselves, that is being stored on computers.
3. The reading level of all articles was appropriate for high school students.

4. Teachers expressed th desire for more opportunities for students to operate the computers with software similar to " Doctor."

5. An editorial decision left the first four activities out of the student materials and contained only in the Teacher's Guide. This should be corrected in the commercial materials.

6. More information is needed on why it is necessary to retrieve and store information in order to present a more balanced approach to the privacy problem.

Biomedical Technology

1. This is an area of great interest to teachers and to students.

2. The topics presented were of interest, but additional topics were suggested.

3. The reading level and complexity of the topics were too high for low ability high school students. The upper half of the high school students did not experience any difficulty with reading or concepts.

4. More hands-on activities were requested but this is a difficult task for this subject.

5. Some concern was expressed over asking the students to function in the role of a lawyer in drawing up model contracts.

Food Technology

1. Overall student interest for this unit was very high and positive.

2. Students reacted very favorably to the types of projects included in this module.
3. Students who had completed the Television unit were keenly aware of how the two technologies interacted.
4. Teachers requested that activities which could be included from other units be identified in the Teacher's Guide.
5. It was suggested that some activities be deleted because of their length and the fact no clear links were drawn with the unit as a whole.

Student Feedback

Students were asked to fill out an activity evaluation form for each activity they completed. In addition, project staff queried students when visiting field test sites as to specific units and activities. The information obtained from these two sources is summarized below by resource unit.

Science, Technology, and Society

1. Overall student reactions were positive to the unit and a high degree of interest was maintained.
2. Students suggested more detailed examples be used with Activities 1, 4, and 6.
3. The reading level of some, but not all, articles was too high for many of the high school students. This was not the case for the community college students.

4. Students considered examples included in the unit as relevant, current, and pertinent to their lives.

5. The concepts presented in this unit were considered thought provoking and important. However, in Activity 6, students suggested the concepts were too difficult as presented.

6. Students responded very positively to the Deprozine Simulation used in Activity 3.

Television

1. Overall student reaction was very positive and a high degree of interest was maintained.

2. Students suggested more activities be included which did not require television viewing.

3. The introductory activity was very interesting and important to the overall understanding of the module.

4. Students reported some of the projects as being too time consuming, as far as requiring time outside of class.

5. Students suggested the social impacts of television could be covered with fewer activities.

Day Care

1. Students expressed concern over the amount of reading.

2. Students suggested some activities be deleted because there was too much repetition.

3. The taped interviews were not received well by students. They

suggested that they should conduct the interviews or have visitors brought to class.

4. Students perceived that they had an opportunity to consider the future and the impact teachnology may have on them as individuals.
5. Students reacted negatively to the number of worksheets included in this resource unit.

Reproduction

1. Students responded positively to this resource unit and to the new information presented.
2. The projects required of students typically produced negative remarks because of the time involved, the out of class work, and the additional research. Students suggested if the number of projects were reduced there would be a more favorable reaction.
3. The lectures and class discussions included by teachers met with positive feedback. The discussions provided students a forum in which questions could be answered that arose while they were working on the projects.
4. Information contained in this unit was new to most students. Students found it very interesting to be exposed to this new information. Students thought that providing definitions would make it easier to understand the concepts presented.

Food Technology

1. Students reacted very favorably to this module and enjoyed the

types of projects which were included.

2. The worksheets were unclear and most students suggested they be revised or deleted.
3. For most students it was a fast-paced unit with enough variety to satisfy individual interests.

Computers and Privacy

1. Students were very positive and enthusiastic about this resource unit. It was considered important and a technology which would become more and more a part of their lives.
2. Students expressed concern and frustration over the projects which called for interviews. Obtaining some of the interviews proved to be too time consuming.
3. Students enjoyed working on the computers and expressed a desire to have more activities that included the use of a computer.
4. In those projects using interviews as a primary source of information, students suggested more visitors/experts be brought to the classroom to provide the information.
5. Students found the topics included in this unit were relevant, important, and pertinent to their lives.

Biomedical Technology

1. The overall student reaction to this resource unit was one of high interest.
2. Generally, the high school students had difficulty with the

vocabulary and reading level. Many suggested a glossary be included with each activity.

3. Students expressed concern over the fact that most of the information had to be obtained from the readings. When the readings were not followed by class discussions or lectures, students did not feel they understood all the issues being presented.

Low-Head Hydropower

1. Students were very enthusiastic and reacted positively to this unit. In geographical areas where low-head hydropower did not appear to be a critical issue, students remained highly motivated and interested.
2. Students responded negatively to the amount of math required in this unit. Some students suggested that the math limited time which could be used to discuss issues.
3. Those classes which implemented the unit as an entire group reported the small group disucssions and assignments as beneficial.
4. The filmstrip used with this unit was met with strong approval. Most students reported it made their projects more relevant and important.

Energy: Technologies, Dilemmas, Options

1. Students were enthusiastic and motivated about the projects included in this unit.

2. Many students responded negatively to the readings included in this unit. However, teacher feedback indicated that this negative reaction may be due to the length of the articles and not to the issues presented.
3. Many students did not see how some of the topics were relevant to their situations.

General Findings

In addition to the unit-specific findings of teachers and students, some general findings were identified that span all modules. Consistently, both teachers and students reported that the print was too small in the student and teacher materials. Students suggested the authors were presenting a topic of relative unimportance or else the print would be of a sufficient size to read. In this first field test the print was small due to budget constraints and not a statement of the unimportance of the topics presented.

The issues and concerns raised by the project staff during the initial development phase about reading levels and the number of readings were also a concern to teachers and students. For the most part, the readings were not considered too difficult by either teachers or students. In those cases where students found an article too difficult, a glossary was suggested. However, the length of the readings and the number proved to be a different issue. Students consistently stated they could have understood the concepts presented with much shorter readings. They also reported that reducing the length or providing

summaries would have maintained a higher degree of interest. In addition to this, both students and teachers wanted the actual number of readings reduced. Teachers suggested that the deleted articles be included in the Teacher's Guides with suggestions on incorporating them. Students reported there was too much repetition and a reduction of the number of readings would solve this problem.

Both the student evaluations and worksheets met with strong student opposition. The opposition focused on the number of the instruments and not necessarily on the content. Students did not mind completing some forms for each unit but felt the worksheets and evaluations for every activity required too much time. Many students suggested that both the evaluations and the worksheets be reduced in number and maintained this would increase the utility of the information obtained.

The final issue consistent across all resource units related to the projects. Most units included several projects to be completed by the students. Students reported the projects were generally too time consuming and did not take into account the other responsibilities students had (e.g., work, clubs, transportation, etc.). Those students having the time to complete the projects found them very rewarding.

When the development of all resource units was completed, teachers were provided with enough material to effectively implement a two-year program. However, teachers had committed to use the program in their classes for a period of only eight to twelve weeks. It was therefore necessary for teachers to choose and use only selected units.

Some teachers reported using a unit for only three weeks while others reported using the same unit for nine weeks.

As a result, the field test varied dramatically from site to site. However, since the purpose of the formative evaluation was to obtain data necessary for judging and then improving the quality of the program, this was not seen as a limitation. In fact, it provided an opportunity to observe individual resource units being used in differing ways and for different purposes. Some teachers wanted to provide only a cursory view of a technology while others wanted students to have a more substantial understanding of the technology and its impact.

The information obtained during this field test was used as a framework on which to revise the program. A proposal was developed to utilize the information obtained during the formative process to attend to the evaluation findings and produce the commerical product. This proposal was not funded.

In summary, the goals of the project were met and the volume of material produced far exceeded the original intent. The resource units were received enthusiastically by the teachers and students. Formative evaluation data collected by the project staff has provided information for revising the experimental materials to produce a commercially-available product.